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Potential Geothermal Energy Use at East Coast Naval Facilities

by
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Applied Physics Laboratory
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for the

Geothermal Utilization Division
Public Works Department

APRIL 1983

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FOREWORD

This report documents the results of a survey of Atlantic Coast Naval facilities as potential geothermal users. The work was tasked by the Civil Engineering Laboratory, Port Hueneme, Calif., and was conducted during July and August 1982.

This report was reviewed by A. M. Katzenstein for technical accuracy.

Approved by
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Capt., CEC, USN
Public Works Officer
25 April 1983

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~~(U)~~ Naval facilities along the Atlantic Coastal Plain were evaluated for their potential as geothermal energy users.

~~(U)~~ Geothermal source temperatures were determined by extrapolating surface temperature gradients to the basement. A list of these temperatures is presented. A table of non-electrical energy consumption at each facility is also presented. The source temperature and non-electrical energy consumption for each facility have been used to determine promising sites for further investigation.

CONTENTS

BACKGROUND

The Arab oil embargo of 1973 underscored the nation's vulnerability to sudden interruption of its oil supply and indicates the need for ensuring that such interruptions do not jeopardize the integrity of our military capability. Consequently the Navy has begun a program to assess the feasibility of replacing some of the petroleum used at its bases throughout the world with geothermal energy.

In this regard, the Applied Physics Laboratory at Johns Hopkins University, Laurel, Md., has been asked to review the Naval and Marine facilities along the Atlantic Coastal Plain. This review is being conducted in two phases. The first phase is to identify those facilities most suitable for geothermal conversion. The second phase is to perform detailed studies of a specific base (or bases) to determine the economic viability of geothermal energy. The first phase is complete. The most promising facilities are in the areas of Charleston, South Carolina, southern Florida, and Norfolk, Virginia.

General studies into the possibility of using geothermal energy at military installations have been explored.[1-4] On the East Coast, several site-specific evaluations have been made that include the Naval Submarine Base, Kings Bay, Ga.; the Naval Air Rework Facility (NARF), Norfolk, Va.; and the Dover Air Force Base, Dover, Del.[5-7] A review of these studies indicates geothermal energy can be economically competitive with oil, especially if there is substantial year-round energy demand.

Before evaluating Navy facilities as potential geothermal energy users, it is first necessary to determine the location of attractive geothermal regions in the Eastern United States. Throughout the world, most elevated geothermal gradient and heat flow zones are located in

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[1] Naval Weapons Center. *Geothermal Energy Resources of Navy/Marine Corps Installations on the Atlantic and Gulf Coastal Plains*, by D. W. Edsall. China Lake, Calif., NWC, March 1980. (NWC TP 6062, publication UNCLASSIFIED.)

[2] Johns Hopkins University, Applied Physics Laboratory. *Definition of Markets for Geothermal Energy in the Northern Atlantic Coastal Plain*, by W. J. Toth. Laurel, Md., JHU/APL, May 1980. (GEMS-002, QM-80-075, publication UNCLASSIFIED.)

[3] Stanford Research Institute. *Assessment of Total Energy Systems for the Department of Defense*, by R. L. Goen. SRI, November 1973. (SRI Project ECU-2513, publication UNCLASSIFIED.)

[4] Battelle Memorial Institute, Pacific Northwest Div. *The Use of Geothermal Energy at Military Installations*, Richland, Wash., BMI, October 1976.

[5] Johns Hopkins University, Applied Physics Laboratory. *Kings Bay, Georgia, Trident Submarine Support Base and Geothermal Energy*, by F. C. Paddison and A. M. Stone. Laurel, Md., JHU/APL, December 1980. (CQO-2972, publication UNCLASSIFIED.)

[6] Johns Hopkins University, Applied Physics Laboratory. *Technical Assistance Report No. 5, Geothermal Space Heating—Naval Air Rework Facility, Norfolk, Va.* Laurel, Md., JHU/APL, June 1980. (QM-80-102, publication UNCLASSIFIED.)

[7] Johns Hopkins University, Applied Physics Laboratory. *Dover Air Force Base, Geothermal Energy Feasibility Study*. Laurel, Md., JHU/APL, December 1981. (QM-81-144, publication UNCLASSIFIED.)

active geological regions, associated with geysers, hot springs, and fumaroles. The East Coast has several hot springs; however, they are not located near any major Navy activity. Although the East Coast has very few surface manifestations of geothermal activity, there are several regions with higher than normal thermal gradients and heat flows (see Figure 1).[8] Along the Atlantic Coastal Plain, these regions receive their extra heat from radiogenic materials buried under sedimentary layers, which act as insulators and hold the heat in. If these high gradient regions are to be viable energy sources, they must have relatively high temperatures and relatively thick insulating sedimentary layer (i.e., greater than 500 meters).

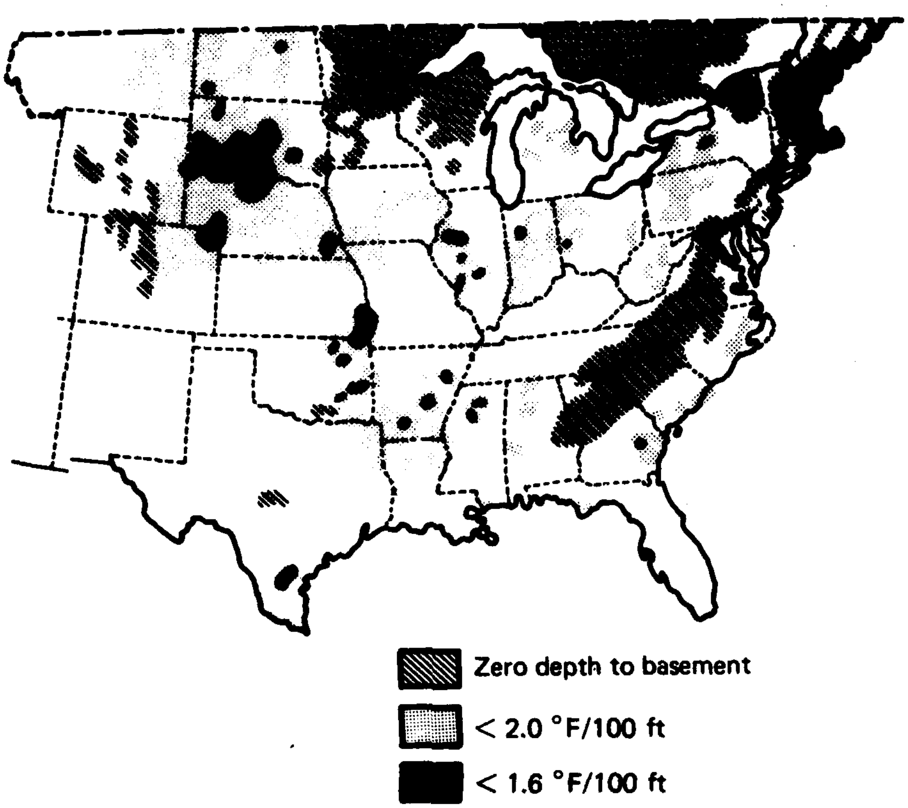

FIGURE 1. Temperature Gradient Data for Eastern United States.[8]

[8] U.S. Geological Survey. Geothermal Gradient Maps of North America, by American Association of Petroleum Geologists. Reston, Va., USGS, 1976.

EVALUATION OF GEOTHERMAL POTENTIAL AT NAVAL FACILITIES

Several regions in the East have both high-temperature gradients and thick sedimentary layers (see Figure 2).[9] Eight areas along the Atlantic Coast have been investigated by Virginia Polytechnic Institute and State University (VPI-SU).[10] Estimated temperatures at the top of the basement (see Figure 3)[11] indicate temperatures over 200°F (93°C) are possible in a few locations, and temperatures over 120°F (49°C) are possible in all eight coastal regions. In addition, western regions of Pennsylvania and New York have predicted temperatures at the top of the basement as high as 220°F (104°C), and in southern Florida the temperature may be even higher because of the greater depth to basement.[11]

Unfortunately many of these geothermal areas are not located near Naval facilities. Over 130 Navy activities located on the East Coast have been considered for geothermal use (Table 1). However, many of these activities are located where the depth to basement is nearly zero (Figure 1), such as Philadelphia, Pa.; Portsmouth, N.H.; Brunswick, Me.; New London, Conn.; Trenton, N.J.; Washington, DC. The remaining Navy and Marine activities are listed in Table 2, along with (1) their total oil, natural gas, and coal energy usage,[12] (2) the approximate distance to the top of the basement, and (3) the best estimate of basement temperature. Electricity usage was not included in Table 2, since East Coast geothermal energy is a low-temperature source and therefore unlikely to provide economical electricity. Where two or more activities are located in the same city, they have been reported as one in Table 2. This combining was done for two reasons: First, in many instances these activities use a central power facility, and second, in instances where each activity has its own power facility, it still may be possible to share a geothermal well.

Since relatively deep wells are required to obtain elevated temperatures, geothermal wells will be expensive. Recent estimates for a 6,800-foot (2073-meter) well in Ocean City, Md., predict a cost of $880,000 for the well and its associated pumps.[13] Even at an interest rate of only 10%, a net income of $100,000 per year is required to amortize the well cost over 20 years. Consequently, a geothermal well has to replace at least $100,000 of fossil fuel to be economical.

As a result, Naval activities that currently spend less than $100,000 per year for non-electrical energy costs are not good candidates for geothermal energy. Since geothermal energy will likely replace only a fraction of the current fossil fuel use, Naval activities whose energy costs are only slightly more than $100,000 are also not likely to be able to fully utilize a geothermal well. From Table 2, the most likely candidates for geothermal energy are located in the following three regions: Florida; Charleston, S.C.; and Norfolk, Oceana, Dam Neck, and Portsmouth, Va. Florida has the hottest predicted temperatures; however, the facilities there

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9 "Tetonic Features," in *The National Atlas of the United States of America*. U.S. Geological Survey, 1976. P. 71.

10 Virginia Polytechnic Institute and State University. *Evaluation and Targeting of Geothermal Energy Resources in the Southeastern United States, Progress Report Virginia Polytechnic Institute and State University*, by J. K. Coasten and L. Glover, III. Blacksburg, Va., VPI&SU, March 1980. (VPI&SU-78ET-27001-8, publication UNCLASSIFIED.)

11 Johns Hopkins University, Applied Physics Laboratory. *Evaluation of Potential Geothermal Resource Areas*, by F. O. Mitchell. Laurel, Md., JHU/APL, July 1980. (QM-79-163R/GT, publication UNCLASSIFIED.)

12 E. J. Duheney. *Defense Energy Information System (DEIS) Energy Consumption* (computer printout). Alexandria, Va., Naval Facilities, Hoffman Bldg., August 1982.

13 Johns Hopkins University, Applied Physics Laboratory. *Ocean City, Maryland, Geothermal Evaluation*. Laurel, Md., JHU/APL, August 1981. (QM-81-109, publication UNCLASSIFIED.)

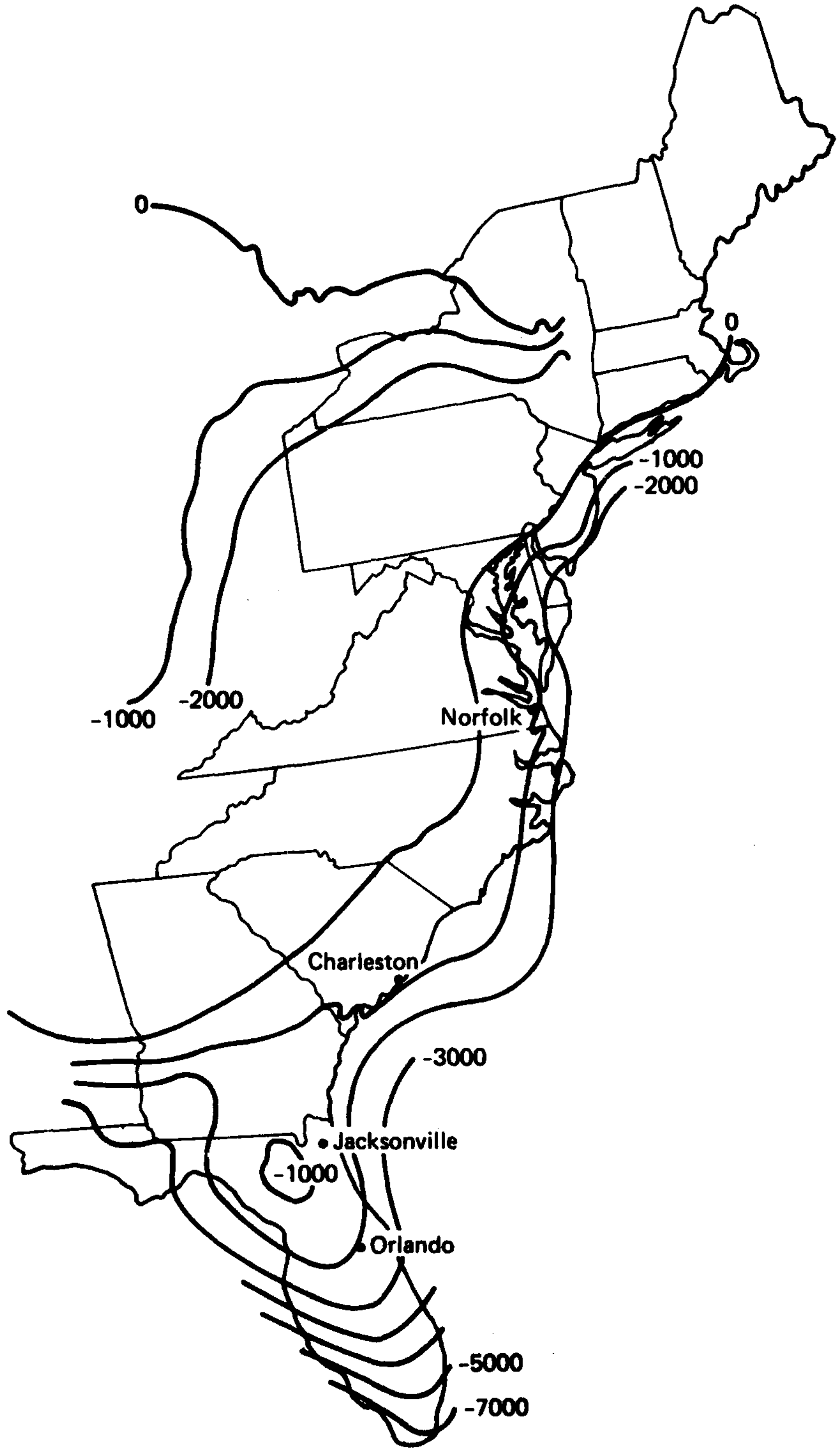

FIGURE 2. Depth to Basement (Meters).[9]

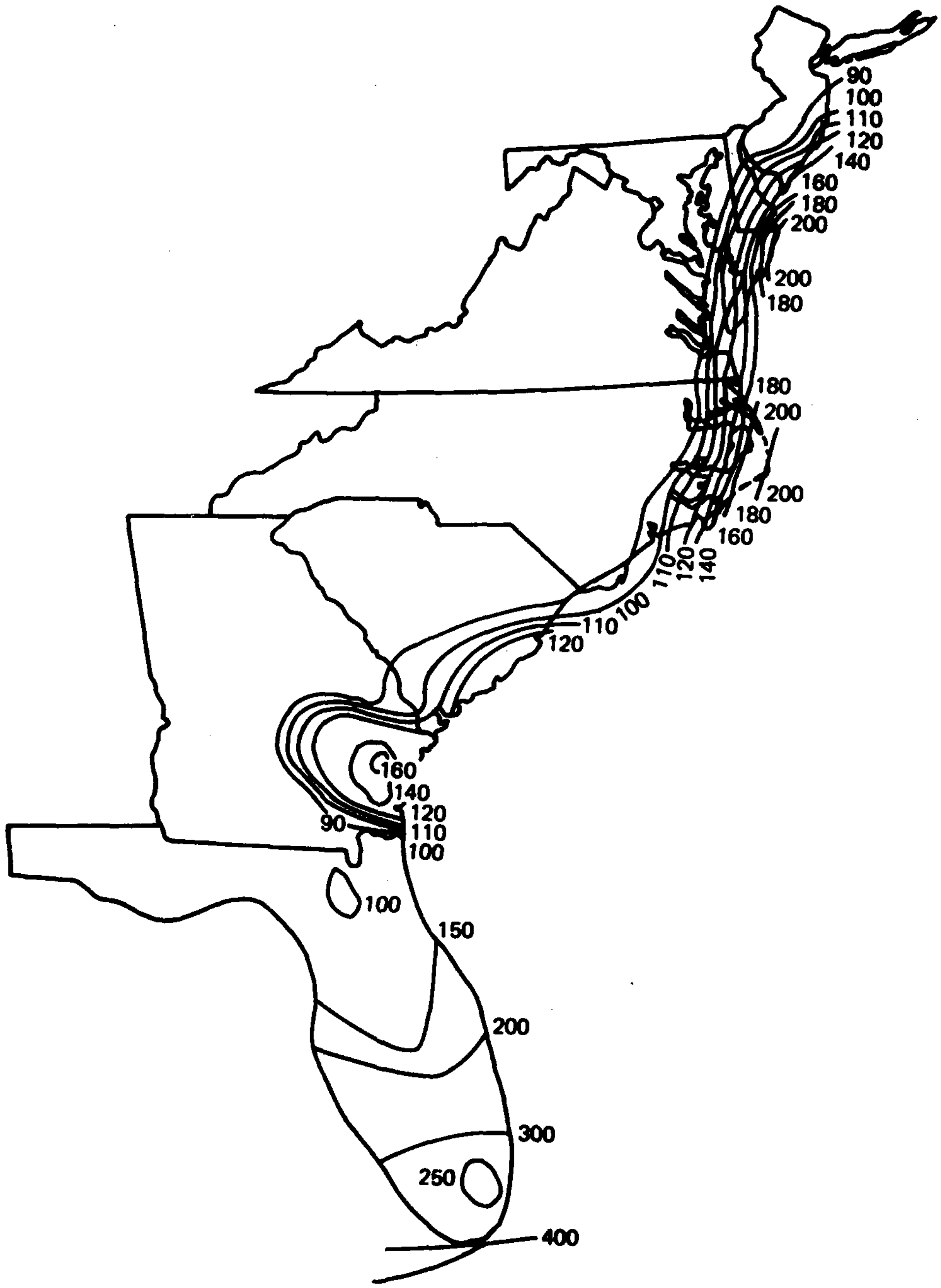

FIGURE 3. Estimated Maximum Temperature (°F) at Bottom of Sedimentary Pile of Atlantic Coastal Plain.[11]

TABLE 1. East Coast Navy and Marine Corps Facilities Considered for Geothermal Energy.

Academy, Annapolis, Md.
Air Develop. Ctr., Warminster, Pa.
Air Engrg. Center, Lakehurst, N.J.
Air Facility, Warminster, Pa.
Air Propulsion Test Ctr., Trenton, N.J.
Air Rework Facility, Cherry Point, N.C.
Air Rework Facility, Jacksonville, Fla.
Air Rework Facility, Norfolk, Va.
Air Sta. Atlanta, Marietta, Ga.
Air Sta., Brunswick, Me.
Air Sta. Cecil Field, Jacksonville, Fla.
Air Sta., Jacksonville, Fla.
Air Sta., Key West, Fla.
Air Sta., Lakehurst, N.J.
Air Sta., Norfolk, Va.
Air Sta. Oceana, Virginia Beach, Va.
Air Sta., Patuxent River, Md.
Air Sta., South Weymouth, Mass.
Air Sta., Willow Grove, Pa.
Air Systems Command Hdqtrs., Arlington, Va.
Air Test Ctr., Patuxent River, Md.
Air Test Facility, Lakehurst, N.J.
Amphibious Base Little Creek, Norfolk, Va.
Aviation Engrg. Service Unit, Philadelphia, Pa.
Aviation Supply Off., Philadelphia, Pa.
Base, Boston, Mass.
Bureau of Medicine and Surgery Washington, DC
Chief of Naval Mtl., Arlington, Va.
Chief of Naval Prsnl., Arlington, Va.
Command Systems Support Activity, Washington, DC
Communication Area Master Station Atlantic, Norfolk, Va.
Communication Unit Cutler, East Machias, Me.
Communication Unit Key West, Fla.
Communication Unit Washington, Cheltenham, Md.
Construction Battalion Ctr., Davisville, R.I.
Damage Control Training Ctr., Philadelphia, Pa.
Education and Training Ctr., Newport, R.I.
Electronic System Command Hdqtrs., Arlington, Va.
Facilities Engrg. Command Atlantic Div., Norfolk, Va.
Facilities Engrg. Command Chesapeake Div., Washington, DC
Facilities Engrg. Command Hdqtrs., Alexandria, Va.
Facilities Engrg. Command Northern Div., Philadelphia, Pa.
Facilities Engrg. Command Southern Div., Charleston, S.C.
Facility Cape Hatteras, Buxton, N.C.
Facility, Lewes, Del.
Fleet Ballistic Missile Submarine Training Ctr., Charleston, S.C.
Fleet Combat Trng. Ctr., Atlantic, Dam Neck, Virginia Beach, Va.
Fleet Mtl. Support Office Mechanicsburg, Pa.
Fleet Training Ctr., Mayport, Fla.
Fleet Training Ctr., Norfolk, Va.
Fuel Depot, Jacksonville, Fla.
Guided Missile School Dam Neck, Virginia Beach, Va.
Hospital, Annapolis, Md.
Hospital, Beaufort, S.C.
Hospital, Cherry Point, N.C.
Hospital, Key West, Fla.
Hospital, Patuxent River, Md.
Hospital, Quantico, Va.
Intelligence Command Hdqtrs., Alexandria, Va.
Intelligence Support Ctr., Suitland, Washington, DC
Marine Barracks, Washington, DC
Marine Corps Air Facility, Quantico, Va.
Marine Corps Air Sta., Beaufort, S.C.
Marine Corps Air Sta., Cherry Point, N.C.
Marine Corps Air Sta. (Helicopter) New River, Jacksonville, N.C.
Marine Corps Base, Camp Lejeune, N.C.
Marine Corps Camp Elmore, Norfolk, Va.
Marine Corps Develop. and Education Command, Quantico, Va.
Marine Corps Hdqtrs. Battalion, Arlington, Va.
Marine Corps Logistics Support Base Atlantic, Albany, Ga.
Marine Corps Recruit Depot, Parris Island, S.C.
Military Sealift Command, Washington, DC
National Naval Medical Ctr., Bethesda, Md.
Naval District Hdqtrs. (COM 01, COM 03, COM 04), Philadelphia, Pa.
Naval District Hdqtrs. (COM 05), Norfolk, Va.
Naval District Hdqtrs. (COM 06), Charleston, S.C.
Naval District Washington Hdqtrs., Washington, DC
Nuclear Power Training Unit, Ballston Spa, N.Y.
Nuclear Power Training Unit, Windsor, Conn.
Observatory (Naval), Washington, DC
Ordnance Sta., Indian Head, Md.
Photographic Ctr., Washington, DC
Polaris Missile Facility Atlantic, Charleston, S.C.
Public Works Ctr., Norfolk, Va.,
Publication and Forms Ctr. Philadelphia, Pa.
Radio Sta., Sugar Grove, W.Va.
Recruit Training Command, Orlando, Fla.
Regional Medical Ctr., Camp Lejeune, N.C.
Regional Medical Ctr., Charleston, S.C.
Regional Medical Ctr., Jacksonville, Fla.
Regional Medical Ctr., Newport, R.I.
Regional Medical Ctr., Orlando, Fla.
Regional Medical Ctr., Ph[illegible]elphia, Pa.
Regional Medical Ctr., [illegible]uth, Va.
Regional Medical Clinic, [illegible]smouth, N.H.
Research Lab., Washing[illegible]C
Sea Systems Command Hd[illegible]lington, Va.
Security Group Activity, [illegible]stead, Fla.
Security Group Activity Chesapeake, Va.
Security Group Activity, W[illegible]arbor, Me.
Security Sta., Washington, DC
Service School Command, Orlando, Fla.
Ship Engrg. Ctr., Arlington, Va.
Ship R&D Ctr., Annapolis Lab, Annapolis, Md.
Ship R&D Ctr., Carderock Lab., Bethesda, Md.
Ships Parts Control Ctr., Mechanisburg, Pa.
Shipyard, Charleston, S.C.
Shipyard, Norfolk, Portsmouth, Va.
Shipyard, Philadelphia, Pa.
Shipyard, Portsmouth, N.H.
Station, Annapolis, Md.
Station, Charleston, S.C.
Station, Mayport, Fla.
Station, Norfolk, Va.
Submarine Base New London, Groton, Conn.
Submarine Support Base, Kings Bay, Ga.
Supply Annex Cheatham, Williamsburg, Va.
Supply Center, Charleston, S.C.
Supply Center, Norfolk, Va.
Supply Corps School, Athens, Ga.
Supply Systems Command Hdqtrs., Arlington, Va.
Support Activity, Brooklyn, N.Y.
Support Activity, Philadelphia, Pa.
Surface Weapons Ctr., Dahlgren Lab, Dahlgren, Va.
Surface Weapons Ctr., White Oak, Silver Spring, Md.
Training Ctr., Orlando, Fla.
Training Equipment Ctr., Orlando, Fla.
Underwater Systems Ctr., Newport, R.I.
Weapons Engrg. Support Activity, Washington, DC
Weapons Sta., Charleston, S.C.
Weapons Sta., Earle, N.J.
Weapons Station, Yorktown, Va.

TABLE 2. Geothermal Data for Selected East Coast Naval Facility Locations.

No.	Location	Approx. temp. at top of basement, °C/°F	Depth to basement, ft/m	Yearly oil, gas, and coal usage (4-81 thru 3-82), 10^6 Btu/$1,000
1.	Key West, Fla.	218/424	26,240/8000	17/162
2.	Buxton, N.C.	93/200	10,000/3050	15/143
3.	Lewes, Del.	66/150	6,500/1983	3.2/27
4.	Orlando, Fla.	65/149	6,560/2000	189/354
5.	Charleston, S.C. (Naval Station)	54/130	4,000/1220	1,412/4,275
6.	Charleston, S.C. (POMFLANT)	54/130	4,000/1220	137/1,084
7.	Mayport, Fla.	52/126	5,250/1600	54/423
8.	Jacksonville, Fla.	51/124	4,920/1500	855/2,660
9.	Jacksonville, Fla. (Cecil Field)	51/124	4,920/1500	285/747
10.	Dam Neck, Va.	49/120	3,500/1067	597/3,169
11.	Oceana, Va.	49/120	3,500/1067	371/848
12.	Kings Bay, Ga.	49/120	1,600/490	6.4/50
13.	Chesapeake, Va.	47/117	2,800/854	[illegible]0/207
14.	Norfolk, Va.	46/115	2,700/8232	3,99[illegible]/23,286
15.	Beaufort, S.C.	46/115	3,900/1190	62/226
16.	Parris Island, S.C.	46/115	3,900/1190	868/3,185
17.	Portsmouth, Va.	43/110	3,900/1190	228/964
18.	Cherry Point, N.C.	41/105	4,600/1402	461/1,514
19.	Scotia, N.Y.	39/102	2,500/700	6.5/50
20.	Camp Lejeune, N.C.	35/95	2,500/760	2,363/11,713
21.	Yorktown, Va.	32/90	2,000/610	346/2,097
22.	Lakehurst, N.J.	29/85	1,200/370	528/3,173
23.	Earle, N.J.	29/85	1,200/370	123/959

have the fewest heating degree days and probably use most of their energy for cooling. Cooling can be supplied by geothermal energy using heat pumps, but this application is more expensive to implement than heating applications. In addition geothermal wells in Florida will cost more since their wells will be deeper because of the low thermal gradient.

CHARLESTON, S.C. SITE STUDY

A trip to Charleston, S.C. revealed that the Polaris Missile Facility Atlantic, Weapons Station (POMFLANT) uses decentralized heating systems located in buildings spread out over several miles. It is not likely that geothermal energy can be used there. The Naval Station at

Charleston has more potential, since it has a centralized coal-burning plant, which supplies 165-psi steam to over half of the facility. If geothermal energy were used to preheat the Station's water from 70 to 120°F, each year it would supply 50×10^6 British thermal units (Btu) of energy and replace $125,000 of coal at $2.50 per million Btu, which looks promising and will be investigated further.

FUTURE PLANS

The second phase in our evaluation of potential Navy geothermal energy users, will be a detailed study of the most promising Naval facilities. The Public Works Center (PWC) in Norfolk, Va., will be evaluated first, since its large size and space heating requirements make it the most attractive site. If the PWC proves not to be a viable geothermal energy site, additional evaluations will be conducted at the Air Rework Facility in Jacksonville, Fla., and at the Naval Station in Charleston, S.C.

CONCLUSIONS

A review of 130 separate Navy and Marine Corps activities on the Atlantic Coastal Plain indicates that there are three regions where geothermal temperatures are relatively high and the Naval activities' non-electric energy use is large enough to utilize the full capacity of a geothermal well. These Naval activities are located in Florida; Charleston, S.C.; and Norfolk, Oceana, Dam Neck, and Portsmouth, Va. Each of these areas will be investigated in further detail.

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